Westinghouse Program Overview

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Introduction

The Westinghouse Solid Oxide Fuel Cell Development Program has been making rapid progress towards commercialization. The vision of a cost-competitive, ultra-high efficiency, environmentally friendly SOFC power generation product line for distributed power and cogeneration applications is nearing a reality. This vision is centered around Pressurized SOFC/Gas Turbine Combined Cycle (PSOFC/GTCC) power generation systems in the 1-100 MWe power range, which are capable of producing electricity at efficiencies between 60% and 75% depending on size and specific turbines selected.

Objectives

The overall objective of the Westinghouse SOFC Development Program is to complete the technology and manufacturing development of the tubular SOFC and SOFC module consistent with taking commercial orders for PSOFC/GTCC power generation systems by late 1999/early 2000. Specific objectives include 1) developing low cost cell materials and manufacturing processes, 2) developing pressurized module technology including stack reformation of natural gas, and 3) demonstrating a commercial prototype, MWe-class PSOFC/GTCC power generation system by the year 2000.

Project Description

The Westinghouse SOFC Development program from 1990-1996 focused on air electrode supported cell development, cell scale-up to commercial size, cell lifetime and voltage stability, thermal cycle capability, natural gas utilization and 25 kWe-class field unit demonstrations. The last major milestone of the current development program is the manufacture and test initiation of a 100 kWe (150 kWe max) atmospheric SOFC power generation system for a European consortium. Manufacturing is ongoing and field operation is scheduled to begin in the first half of 1997.

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The Westinghouse SOFC Development Program from 1997-2001 will focus on the development of 1) low cost cell manufacturing, 2) low cost module materials, and 3) pressurized technology including natural gas reformation. The program will culminate with test initiation of a commercial prototype, MWe-class, PSOFC/GTCC power generation system at a customers site by 2000 and the commissioning of a large scale SOFC manufacturing facility by 2001. We are currently seeking a host utility and funding support for this MWe-class demonstration from DOE, utilities, and potential business partners.

Accomplishments

The SOFC Power Generation organization is proud of and encouraged by its technical accomplishments over the past few years. The major accomplishments include:

- Over 8700 hours of power operation for a 25 kWe SOFC power generation system with no voltage degradation. Figure 1 shows a plot of the module voltage, current, and power versus operating time.

- Nearly 7½ years of power operation for two cells with a voltage degradation rate of about 0.5% per 1000 hours. Figure 2 shows the voltage versus time plot for one of these cells.

- Air electrode composition change which solved the thermal cycle cracking problem. Figure 3 presents a bar graph of our cumulative thermal cycle experience with the new air electrode material. Figure 4 presents a V-I comparison before and after 106 thermal cycles to room temperature.

- Successful development of our air electrode supported cell, and successful scale-up from a 50 cm active length cell (65 watts per cell at 1 atmosphere) to a 150 cm active length, larger diameter cell (210 watts per cell at 1 atmosphere). Figure 5 shows photographs of our commercial size cell and compares it to our old 50 cm cell.

- Successful pressurized cell testing up to 15 atmospheres in collaboration with Ontario Hydro Technologies achieving a SOFC power output record of 280 watts per cell. Figure 6 presents power versus current density test results from 1 to 15 atm.

- Major cost reduction successes including air electrode supported cell, plasma spray interconnection, sintered fuel electrode, low cost air electrode material. Figure 7 shows the progress made in developing lower cost designs and processes. Figure 8 presents a V-I comparison of a sintered versus a EVD fixed fuel electrode.

- Construction and commissioning of a 4 MWe per year Pilot Manufacturing Facility as shown in Figure 9.

- Initiation of commercial size cell production for the first 100 kWe atmospheric SOFC power generation system. Figure 10 shows the layout of the 100 kWe stack and Figure 11 shows an isometric drawing of the power system.

Applications

Our development program is now focused on commercializing a product line of PSOFC/GTCC power generation systems covering the size range 1-100 MWe. The early market entry units will be in the 1-5 MWe range. Other applications may include cogeneration units in the 500 kWe to 1 MWe range. In this small size range, the combined cycle systems are capable of producing electricity in the 60-70% efficiency range depending on the gas turbine selected. As the product matures, larger size combined cycle systems will be offered. In larger sizes, such PSOFC/GTCC systems can achieve efficiencies greater than of 70%.

Acknowledgments

Westinghouse acknowledges the guidance and assistance of Mr. William C. Smith, Project Manager, Office of Product Technology Management, METC, in the course of this Cooperative Agreement spanning the period from December 1, 1991 through November 30, 1996.

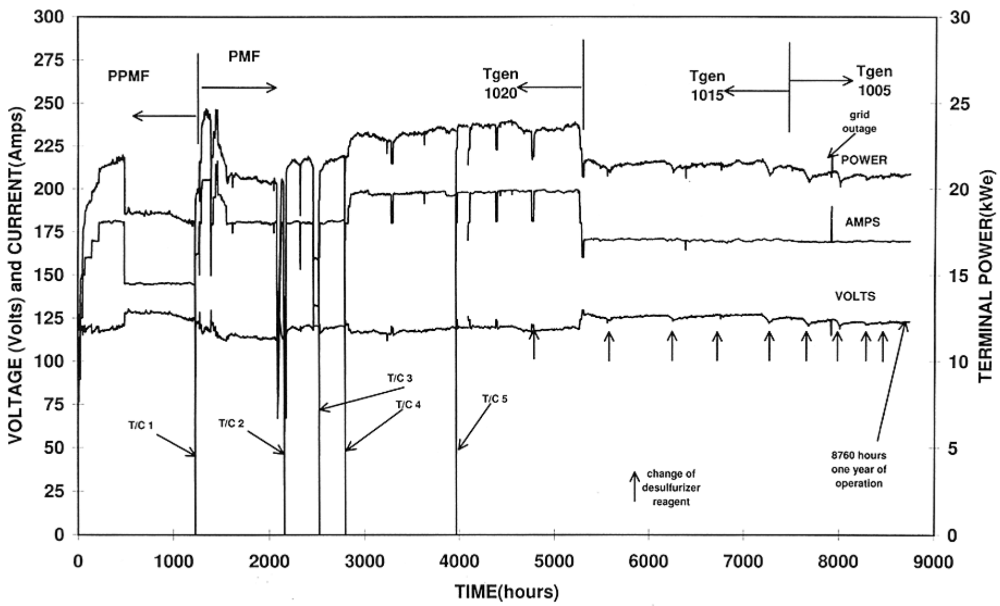

Figure 1— Plot of module voltage, current, and power versus operating time for 25 kWe system.

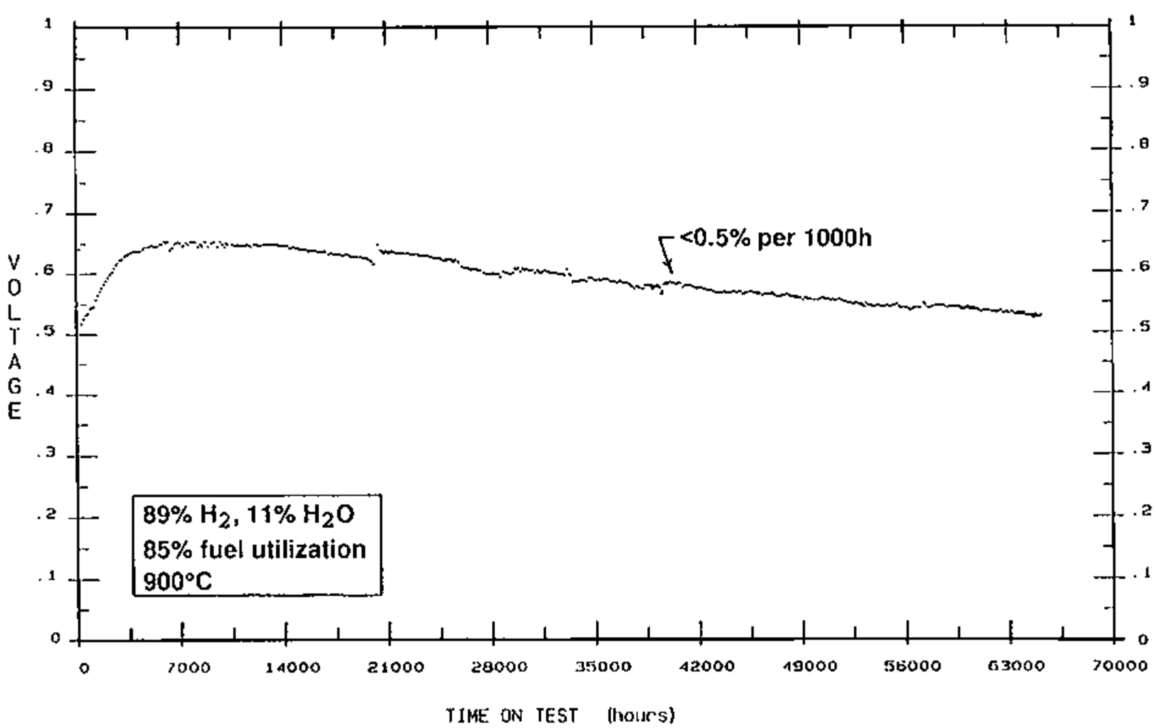

Figure 2 — Cell voltage versus time for longest operating SOFC.

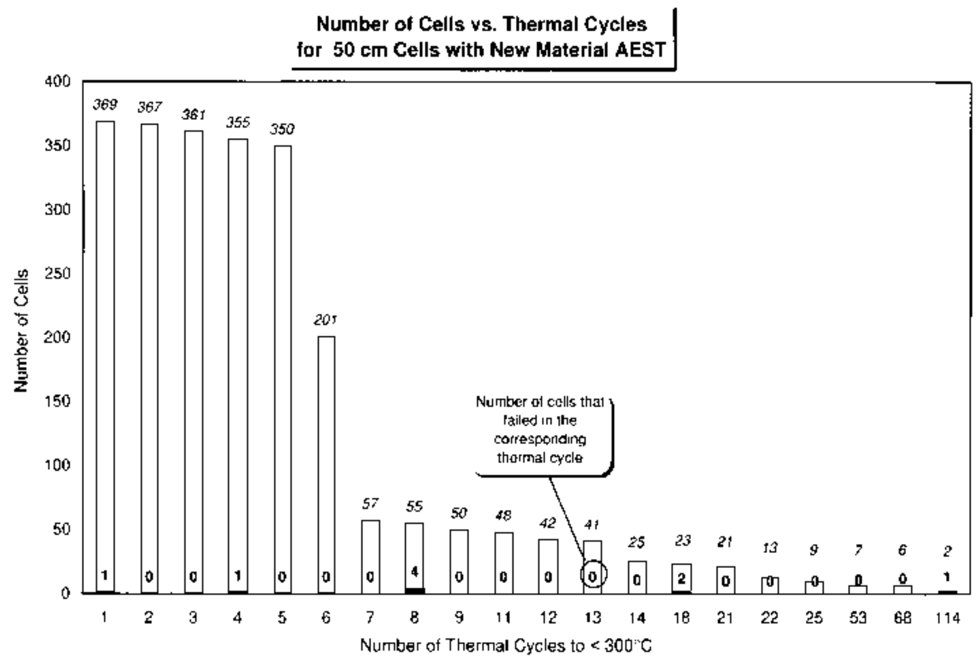

Figure 3 — Bar graph of cumulative thermal cycle experience with new air electrode material.

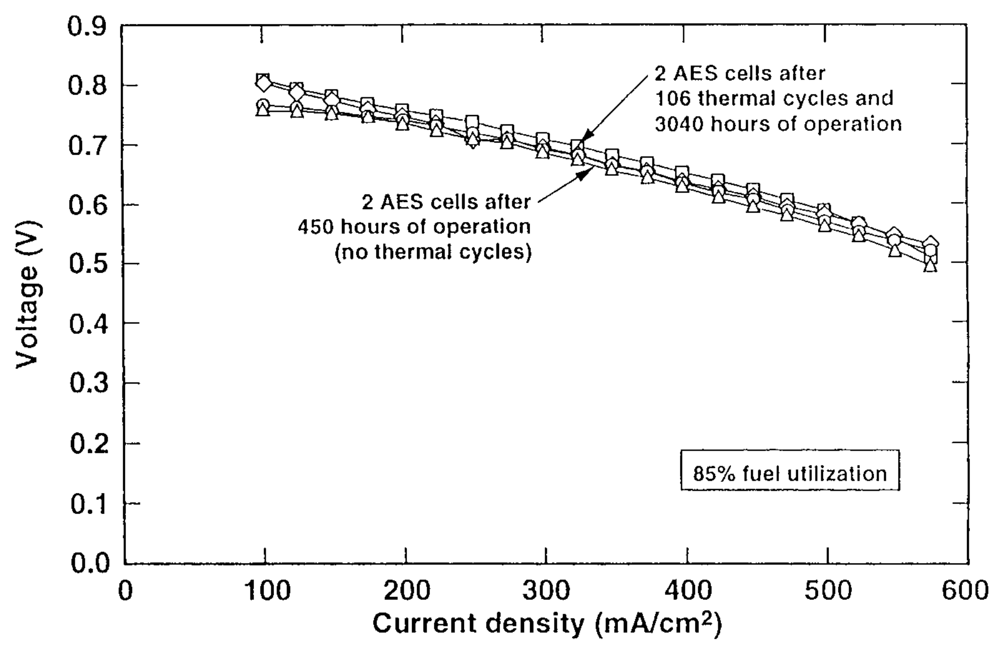

Figure 4 — V-I comparison before and after 106 thermal cycles to room temperature.

Figure 5 — Photographs of commercial size cell compared to old 50 cm cell.

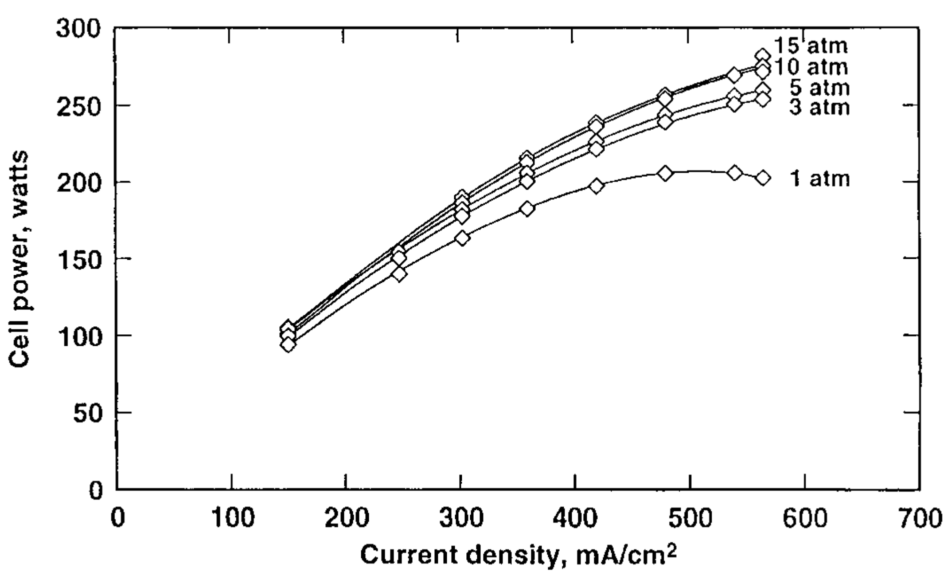

Figure 6 — Power versus current density test results for different pressures.

In Prod.	Dev. → Prod.	In Dev.	
✓			AES Cell (No PST)
✓			Commercial Length - 1500 mm
✓			Interconnections via Plasma Spray
✓			Electrolyte via EVD
✓			Anode Sprayed, then Fixed via EVD
	✓		Anode Sprayed, then Sintered
		✓	Co-sintered Interconnection
		✓	Sintered Electrolyte

Figure 7 — Cell design and processing improvement.

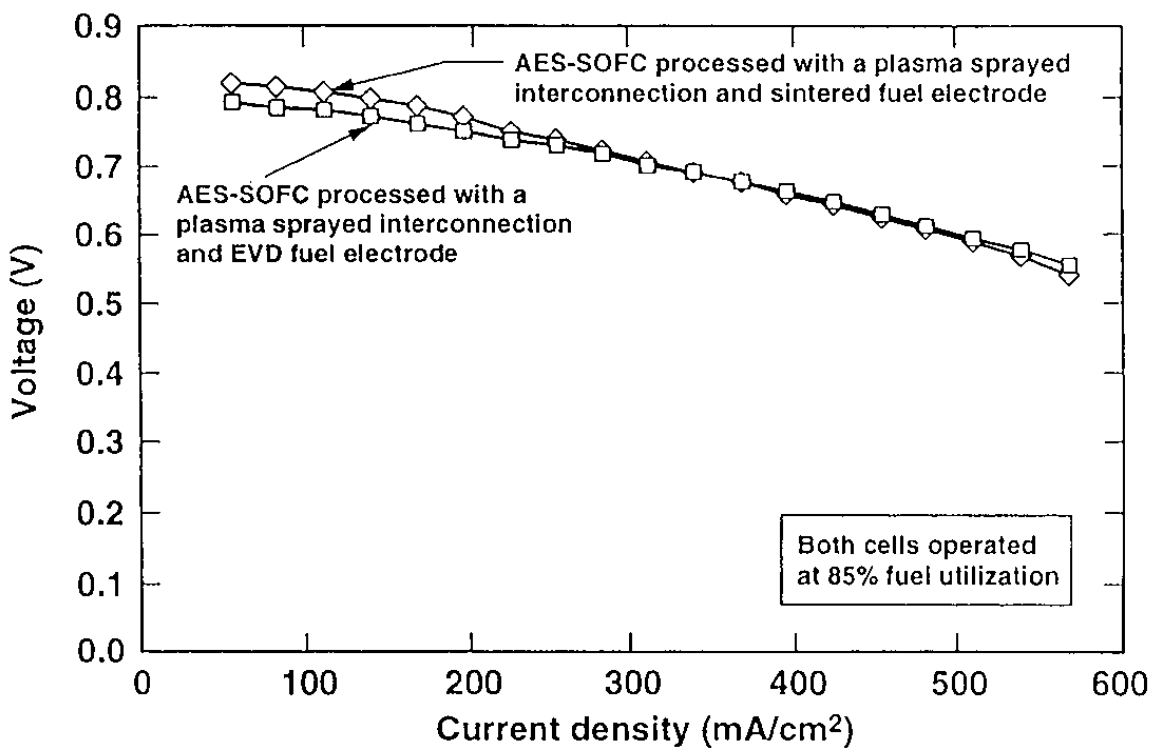

Figure 8 — V-I comparison of a sintered versus a EVD fixed fuel electrode.

Figure 9 — 4 MWe per year SOFC Pilot Manufacturing Facility.

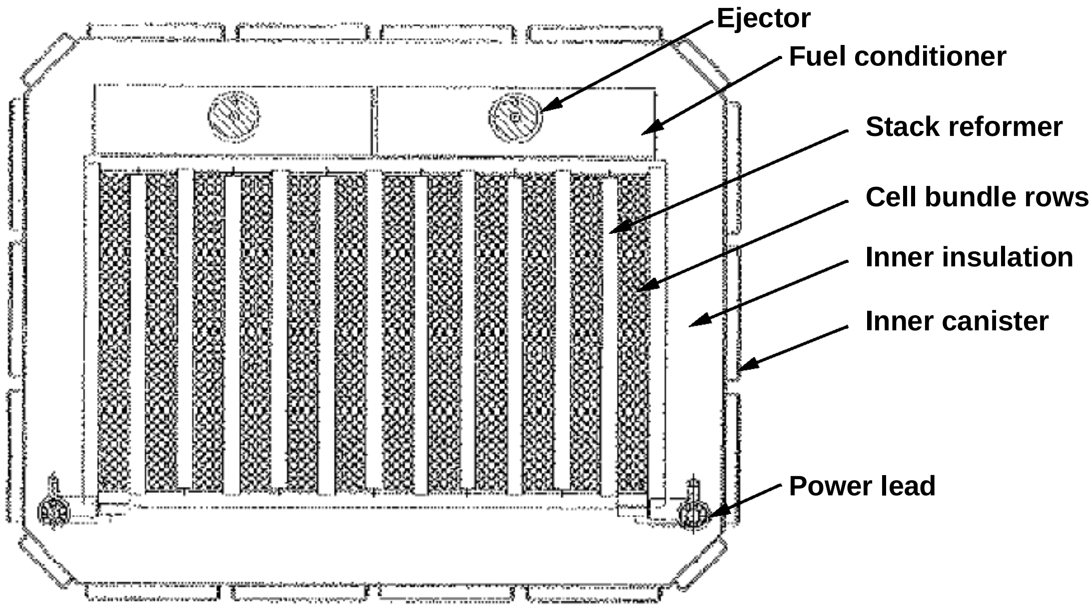

Figure 10 — Layout of the 100 kWe stack

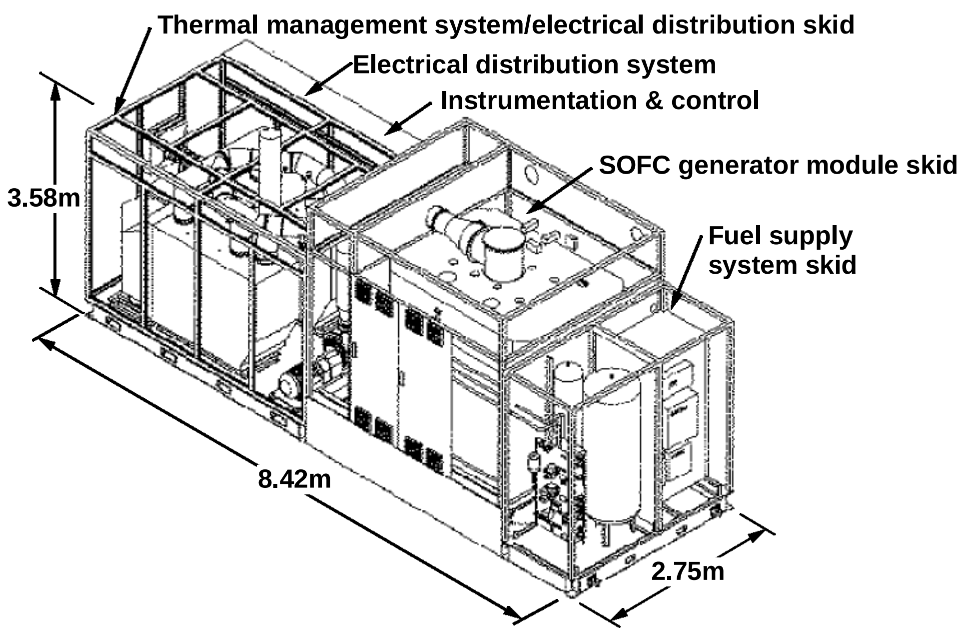

Figure 11 — Isometric drawing of the 100 kWe power system.